

## Clinical Focus Article

# Increase in Pain Assessment Rate with the Use of the Visually Enlarged Numerical Rating Scale: A Retrospective Before-and-After Study

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### ABSTRACT

**Background:** Self-report pain assessment scales help prevent the underestimation of pain and contribute to effective pain relief and person-centered care.

**Aim:** To assess the effectiveness of the visually enlarged 0–10-point numerical rating scale (NRS-V) for pain management in mechanically ventilated patients under light sedation.

**Methods:** This retrospective before-and-after study was conducted at a university hospital in Japan (control phase, April 2016 to May 2017; intervention phase, June 2017 to June 2018). The NRS-V was used at each bedside during the intervention phase, while the NRS-V was not applied during the control phase. The patients who were mechanically ventilated for  $\geq 48$  h were included in this study. The pain assessment rates using the NRS (visual or oral version) and patient outcomes were compared between the control and intervention groups.

**Results:** Overall, 196 mechanically ventilated adult patients were enrolled (control group, 97; intervention group, 99). The proportion of self-reported pain assessments using the NRS-V was significantly higher in the intervention group than in the control group (63.3% vs 36.7%,  $P < 0.001$ ). On multivariate regression analysis, the intervention was associated with a decreased incidence of agitation (Poisson coefficient,  $-0.82$ ; 95% confidence interval,  $-1.47$  to  $-0.16$ ).

**Conclusions:** The NRS-V was associated with increased use of the pain assessment tool and decreased agitation in mechanically ventilated patients.

**Keywords:** Critical care, critical care nursing, pain, pain management

### INTRODUCTION

Pain is a frequent event associated with patient outcomes in the intensive care unit (ICU). During their ICU stay, up to 50% of patients experience moderate-to-severe pain (Chanques et al., 2006; Li & Puntillo, 2006; Chanques et al, 2007; Payen et al, 2007). According to a recent report, approximately 10% of patients experience pain at rest and 27% experience pain during various

nursing interventions (Olsen et al., 2021). Pain is associated with an acute stress response, including changes in heart rate and blood pressure, and psychological distress, often manifesting as agitation (Lewis et al, 1994; Jaber et al, 2005). Moreover, untreated pain is a major source of both chronic pain and a lower health-related quality of life (Kehlet et al, 2006; Langerud et al, 2018). Therefore, effective pain management is associated with better patient outcomes. (Robinson et al, 2008; Payen et al, 2009; Skrobik et al, 2010).

Accurate pain assessment is essential for effective pain management in ICU patients and is a daily challenge for nurses and clinicians. This is because most ICU patients are unable to verbally self-assess their pain due to consciousness-related changes, ventilation, or administration of analgesics (Skrobik et al, 2010). As a result, pain remains under-evaluated and under-treated (Puntillo et al, 2002; Shannon & Bucknall 2003; Payen et al, 2007). The use of self-report pain assessment scales is important to avoid underestimating pain. A recent guideline recommends routinely using self-report and behavioural pain assessment tools for ICU patients (Devlin et al, 2018). In particular, the visually enlarged 0–10-point numerical rating scale (NRS-V) is considered the best self-report pain scale for critically ill adults (Devlin et al, 2018). It has high sensitivity and negative predictive values and is accurate and easy to use compared to the oral 0–10-point numerical rating scale (NRS-O). Therefore, it is the best pain assessment tool for ICU patients (Chanques et al, 2010; Rahu et al, 2015). However, very few studies have focused on improving pain assessment in mechanically ventilated patients. Hence, we conducted a retrospective before-and-after study aimed at improving the method of pain assessment for ventilated patients under light sedation.

Our study primarily sought to evaluate the differences in the proportion of self-reported pain assessment between the two phases, before and after the introduction of NRS-V. The secondary objective was to investigate the impact of pain management on patient outcomes.

## **METHODS**

### **Design**

This study was a retrospective before-and-after study conducted between April 2016 and June 2018 at a university hospital.

### **Participants**

The study included all patients admitted to the ICU (12 of a total of 800 hospital beds) who met the following criteria: (1) age  $\geq$  20 years and (2) mechanical ventilation for  $\geq$  48 h. The exclusion criteria were as follows: (1) post-resuscitation, (2) a history of psychosis or neurological disease, and (3) mechanical ventilation for  $\geq$  24 h before ICU admission.

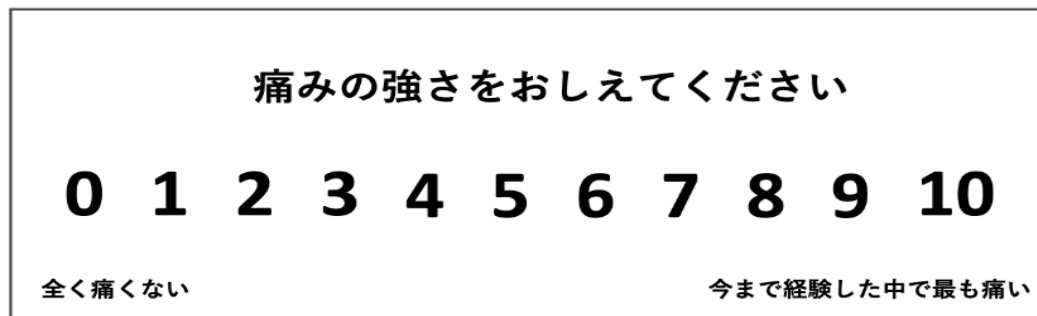
### Interventions

The researcher prepared the NRS-V at each bedside during the intervention period (Figure 1). The analgesia and sedation management protocols were not changed from control phase.

**Control phase:** During this phase (from April 2016 to May 2017), the NRS-V was not used to assess pain; bedside nurses instead evaluated pain using the behavioural pain scale (BPS) and NRS-O (Payen et al, 2001) as standard practice. The BPS includes three main parts: face status, movement of the upper limbs, and moaning in non-intubated patients. This scale ranks pain from 3 to 12 points, with scores of  $\geq 6$  points indicating the presence of moderate-to-severe pain requiring treatment.

### Figure 1.

*Visual Numerical Rating Scale*



**Intervention phase:** During this phase (from June 2017 to June 2018), bedside nurses used the NRS-V together with the BPS to evaluate pain. The NRS-V was printed and enlarged to be easily visible to ICU patients, as they often experience sensory deficiencies. Nurses were encouraged to use the NRS-V for subjective and objective pain assessment.

### Patient management

In our ICU, pain, sedation, and delirium were assessed six times a day. Specific pain and sedation protocols, such as a nurse-driven sedation protocol, were not implemented in clinical settings. As recommended in the recent Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU (PADIS) guidelines (Devlin et al, 2018), clinicians prioritised the use of propofol and dexmedetomidine, but withheld the use of benzodiazepine to avoid deep sedation. Patients received fentanyl according to standard care practices. If the analgesia was deemed inadequate, the dose of fentanyl was adjusted, or acetaminophen was administered for additional pain relief. If the patient developed delirium or progressed to a state of agitation, ICU nurses and clinicians sought and treated the reason for the changes in mental status.

Additionally, ICU nurses initiated non-pharmacological interventions, such as environmental adjustment. If further intervention was required, the administration of a psychotropic drug was considered.

#### **Data collection procedure**

All patient data were retrospectively collected from electronic medical records. The number of times pain assessment was performed, and the degree of pain were collected during the ICU admission. The NRS-O was used in the control phase, while the NRS-V was implemented during the intervention phase. In both phases, the BPS was employed for the evaluation of pain when intubated patients were unable to self-report with the NRS. We collected data regarding which tools were used to assess pain. In the ICU, pain assessment is performed six times a day (2:00, 6:00, 10:00, 14:00, 18:00, and 22:00). The rate of self-reported pain assessment was calculated as the proportion of times when patients self-reported their pain, divided by the total number of times pain was assessed. Data on demographics, comorbidities, reason for ICU admission, disease severity score, laboratory values, duration of mechanical ventilation, length of ICU stay, and ICU and hospital outcomes were extracted. Acute physiology and chronic health evaluation (APACHE II) scores were calculated within 24 hours of ICU admission.

The Richmond Agitation-Sedation Scale (RASS) (Sessler et al, 2002; Ely et al, 2003) was used to evaluate the patient agitation level, whereas the confusion assessment method for the ICU was applied for delirium (Ely et al, 2001). An agitation event was defined by a RASS level >1 (Sessler et al, 2002; Ely et al, 2003). Severe pain events were defined by either a BPS score of >7 or an NRS score of >6 points (Chanques et al, 2006).

#### **Statistical analysis**

Descriptive data were presented as numbers and percentages, while continuous data were presented as medians and interquartile ranges (IQRs). Baseline characteristics and outcomes were compared using the Mann-Whitney U test for continuous variables, and Pearson's chi-squared or Fisher's exact test was employed for categorical variables. We examined the associations between the intervention and the incidence of agitation after adjusting for potential confounding variables using a multivariate Poisson regression model, and results were expressed as coefficients with 95% confidence intervals (CIs) for each variable. Differences with *P*-values of <0.05 indicated statistical significance. All analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA).

#### **Ethics statement**

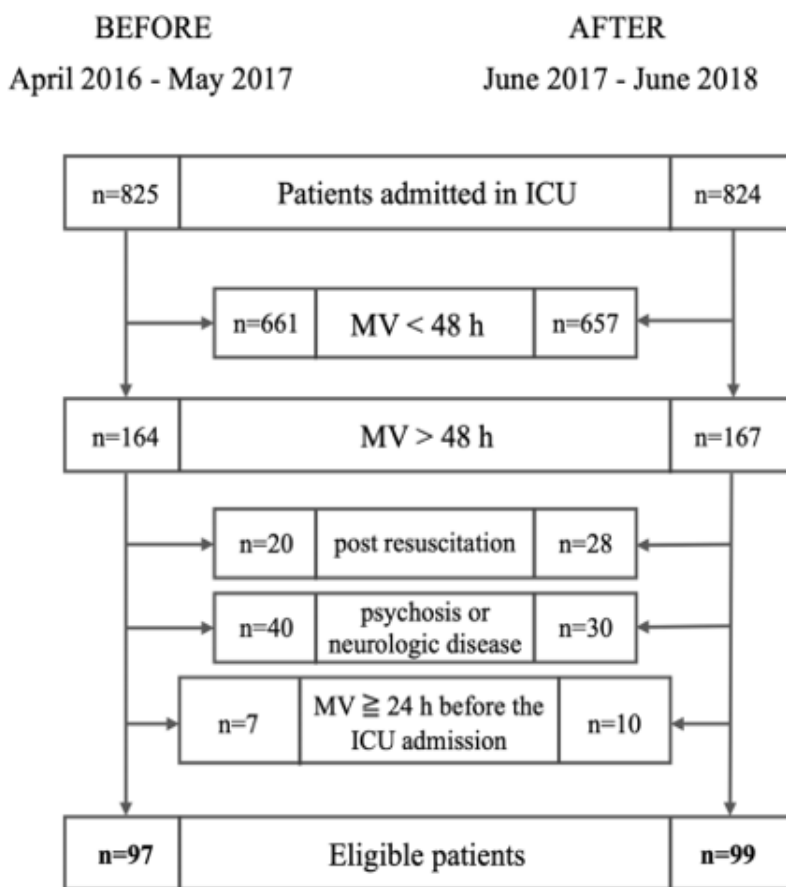
This study was approved by the ethics committee of our institution. The need for informed consent was waived by the Institutional Review Board because of the non-invasive observational design of the study. This work was carried out in accordance with the ethical standards set forth in the Helsinki Declaration of 1975.

## RESULTS

A total of 196 mechanically ventilated adult patients were enrolled (control group, n=97; intervention group, n=99). The median age was 65 (IQR, 57–76) years. The median APACHE II score at enrolment was 22 (IQR, 17–28) points. The main reason for ICU admission was cardiovascular disease. Moreover, patient characteristics were similar between the two groups (Table 1). Interestingly, there were no significant differences in patient demographics between the control and intervention groups. Figure 2 shows the flowchart of the study.

**Figure 2.**

*Flowchart of the Study*



\*ICU, intensive care unit; MV, mechanical ventilation

**Table 1.**  
*Patient Demographics of the Control and Intervention Groups*

Variable	Control (n=97)	Intervention (n=99)	P-value
Age in years, median (IQR)	69 (58–76)	69 (54–77)	0.97
Male sex, n (%)	61 (63)	57 (58)	0.47
APACHE II score, median (IQR)	21 (18–28)	22 (16–27)	0.71
Charlson comorbidity index, median (IQR)	2 (1–4)	2 (0–3)	0.18
<b>Coexisting conditions, n (%)</b>			
Diabetes	31 (32)	25 (25)	0.23
Hypertension	33 (34)	38 (38)	0.53
Solid tumours	23 (24)	21 (21)	0.68
<b>Reason for ICU admission, n (%)</b>			
Cardiovascular	45 (46)	45 (46)	1
Respiratory	18 (19)	27 (27)	0.18
Abdominal surgery	8 (8)	4 (4)	0.25
Sepsis	18 (19)	11 (11)	0.48
Other	8 (8)	12 (12)	0.16

APACHE II = acute physiology and chronic health evaluation II; ICU = intensive care unit; IQR = interquartile range

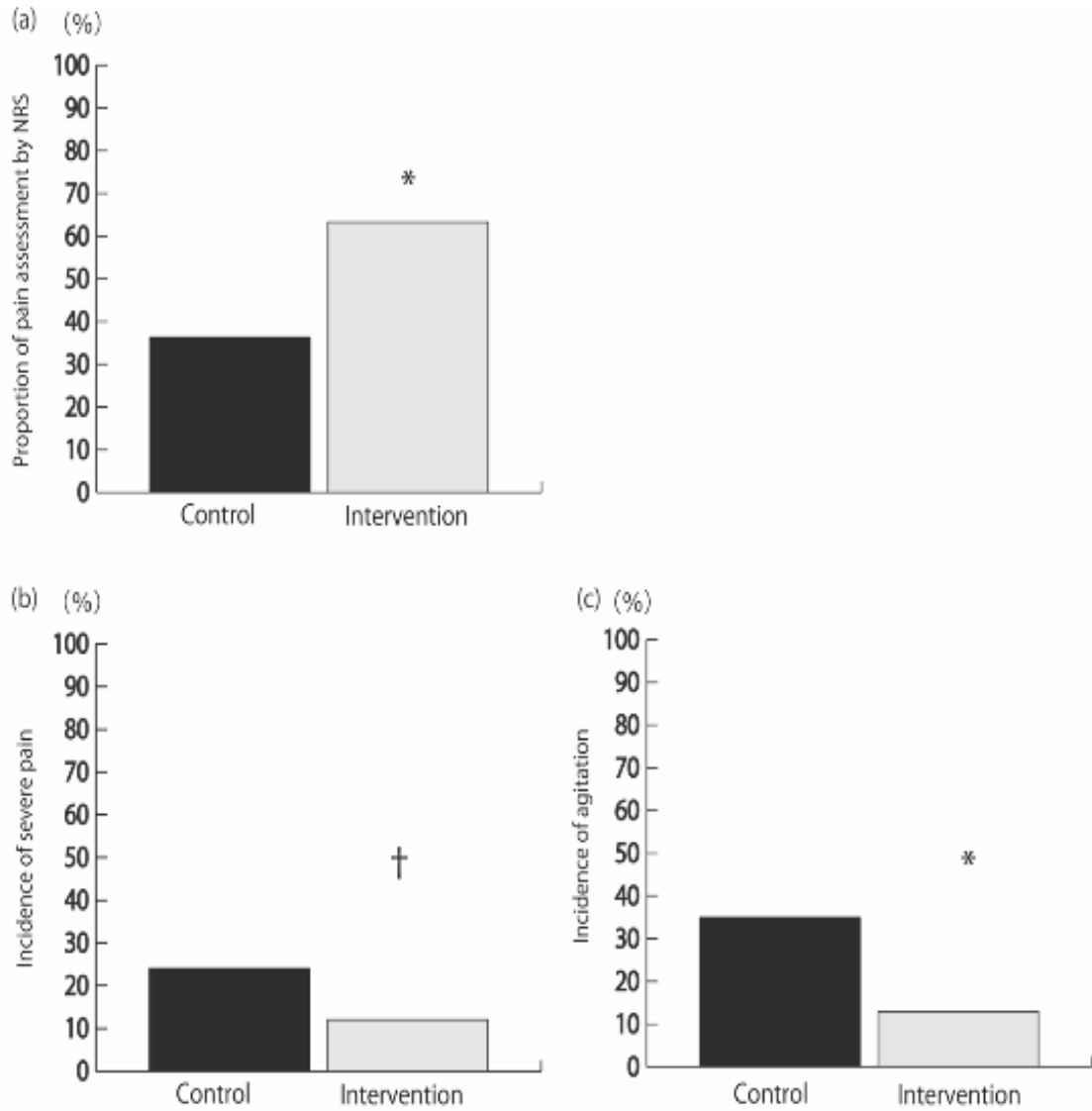
Figure 3 shows the proportion of self-reported pain assessments in mechanically ventilated patients using the NRS (visual or oral version). During the intervention phase, the proportion of self-reported pain assessments significantly increased compared to the control phase: 63.3% vs 36.7% ( $P<0.01$ ). The incidences of severe pain, defined by an NRS score  $>6$  points, and agitation, defined by a RASS level  $>1$ , were significantly lower in the intervention group: 12% vs 24% ( $P=0.034$ ) and 13% vs 35% ( $P<0.01$ ), respectively (Figure 4).

The clinical outcomes are presented in Table 2. No significant differences in the duration of mechanical ventilation, median length of stay, and mortality in the ICU were found between the two groups. Furthermore, there were no significant differences in the duration of delirium and coma.

Figure 4 shows the results of multivariate regression analysis. Multivariate regression analysis demonstrated that the incidence rate of agitation decreased with the use of intervention (Poisson coefficient,  $-0.82$ ; 95% CI,  $-1.47$  to  $-0.16$ ). However, the severity of disease, use of sedatives, and presence of delirium were not significantly associated with the incidence of agitation.

**Figure 3.**

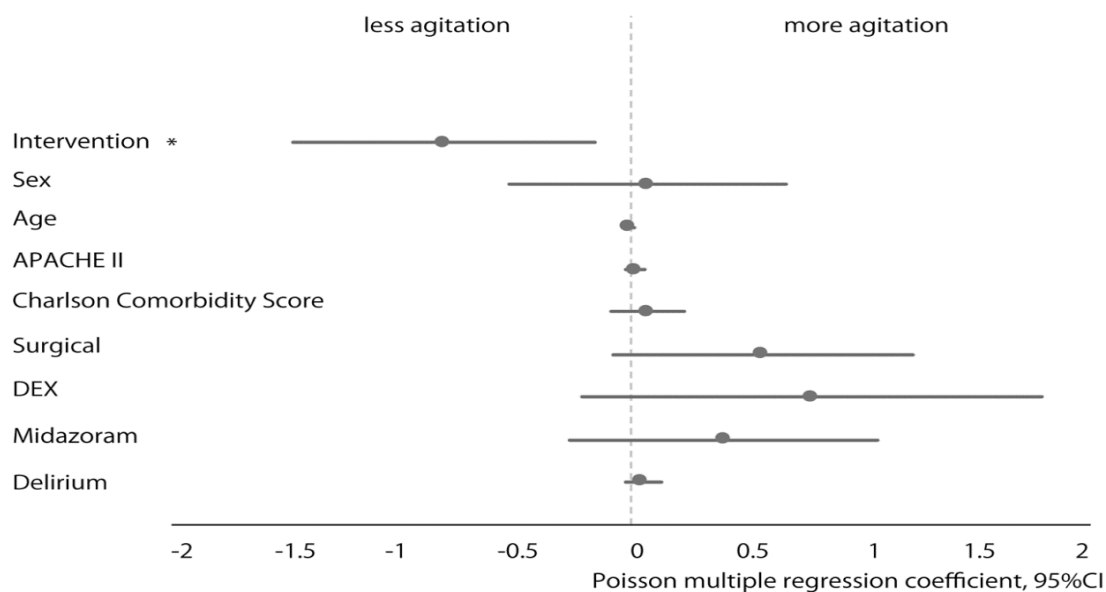
Comparison of the (A) Pain Assessment Rate Using the Numerical Rating Scale (NRS) (B) The Incidence of Severe Pain, and (C) the Incidence of Agitation Events Between the Control and Intervention Groups





**Figure 4.**

Comparison of (A) the Proportion of Self-Reported Pain Assessments Using the Numerical Rating Scale (NRS), (B) the Incidence of Severe Pain, and (C) the Incidence of Agitation Events Between the Control and



\*APACHE II = acute physiology and chronic health evaluation II; DEX = dexmedetomidine.

**Table 2.**

*Clinical Outcomes of Mechanically Ventilated Patients Under Light Sedation.*

Variable	Control (n=97)	Intervention (n=99)	p-value
Length of ICU stay, median days (IQR)	10 (7-16)	10 (7-16)	0.65
ICU mortality, n (%)	14 (14)	14 (14)	0.95
28-day mortality, n (%)	12 (12)	17 (17)	0.34
Mechanical ventilation days, median (IQR)	7 (5, 13)	8 (5, 14)	0.11
RASS level ICU day 1, median (IQR)	-4 (-5, -2)	-4 (-5, -1)	0.23
Delirium days within 7 days, median (IQR)	1 (0, 3)	1 (0, 3)	0.88
Coma days within 7 days, median (IQR)	2 (1, -4)	3 (1, -4)	0.84
*DFCFDs within 7 days, median (IQR)	2 (0, -4)	1 (0, -3)	0.4
<b>Medication</b>			
Fentanyl, n (%)	96 (99)	97 (98)	1
Propofol, n (%)	89 (92)	88 (89)	0.63
Benzodiazepine, n (%)	21 (22)	22 (22)	1
Dexmedetomidine, n (%)	84 (87)	77 (78)	0.17

FCFDs, delirium-free and coma-free days; ICU, intensive care unit; IQR, interquartile range; RASS, Richmond Agitation-Sedation Scale



## DISCUSSION

In this study, we examined the effectiveness of the NRS-V scale for pain management in mechanically ventilated patients under light sedation. The results showed that using the NRS-V in the ICU increased the proportion of self-reported pain assessment. The use of the tool was also associated with a significant decrease in the incidence of severe pain and agitation.

The proportion of self-reported pain assessments using the NRS was significantly higher during the intervention phase than during the control phase (Figure 1). A previous observational study similarly showed increased use of pain assessment tools with systematic pain management (Chanques et al, 2006). In the control phase, nurses evaluated patients' pain using the NRS-O when possible.

However, it is difficult for mechanically ventilated patients to communicate pain with gestures and head nods. The inability of patients to communicate or verbalise pain is a known barrier to the assessment and management of pain in ICU patients (Alotni et al, 2022). These difficulties are largely due to the complex nature of critically ill patients and the challenges that affect the pain assessment process within the critical care environment. To address this issue, in the intervention phase, the NRS was modified to a visually enlarged form (NRS-V) to be easily visible to the ICU patients and enable nurses to evaluate their pain more easily. Our results suggest that using the NRS-V supports the increase in the proportion of self-reported pain assessments.

This study showed that an intervention as simple as the NRS-V can decrease the incidences of severe pain and agitation (Figure 2). A convenient tool such as the BPS can assess pain, but an accurate subjective assessment tailored to the patient would be preferable. Although the BPS has been validated across large samples of medical, surgical, and trauma ICU patients (Yu et al., 2013; Dehghani et al., 2014; Gélinas et al, 2017), the definition of pain emphasises its subjective nature (Raja et al, 2020). According to the International Association for the Study of Pain, pain intensity can be evaluated only by the person experiencing the pain (Raja et al, 2020). The BPS is important in assessing pain among critically ill adults who are unable to self-report pain; however, self-reporting pain assessment tools are more credible for accurately determining pain experiences. Pain assessment using a self-reporting tool would help prevent the underestimation of pain in patients.

In this study, the multivariate regression model revealed that the intervention was a significant factor in decreasing the incidence of agitation after adjusting for age, sex, severity of disease, and use of sedatives. Pain is known as one of the risk factors for agitation (Jaber et al, 2005). In the intervention phase of our study, the decreased incidence of severe pain may have affected the incidence of agitation. A prospective multi-centre observational study showed that pain assessment was associated with reduced consumption of sedative drugs and a

shortened duration of mechanical ventilation (Payen et al., 2009). In our study, clinical outcomes, such as duration of mechanical ventilation and length of ICU stay, were not significantly different between the control and intervention phases. A possible explanation for this result is that a more effective pain management protocol was not applied in our ICU. A multidisciplinary quality improvement study based on pain assessment using NRS-V and BPS or BPS-NI (BPS for non-intubated patients) along with an analgesia protocol showed that a decreased incidence of severe pain while turning patients during routine care procedures was associated with reduced adverse outcomes in patients in the ICU (De Jong et al., 2013). Pain management protocols with an increased focus on the therapeutic benefit of reassessing a patient's pain are needed to increase clinical utility and provide more targeted pain treatment. Although a regular assessment of pain intensity improves pain management, systematic pain treatment is needed to improve patient outcomes.

### **Strengths and limitations**

This study has some important limitations. First, it was a single-centre observational study; the findings may not be generalisable to other institutions. Moreover, the retrospective design allowed us to observe the participants' real-world behaviours; however, we could not discern how the staff assessed pain directly. Additionally, we collected the pain assessment data using NRS; thus, it may not reflect staff behaviour. Second, the pain intensity and incidence of agitation events were observed only when the patients were at rest. Pain associated with an ICU stay can also occur during surgical procedures, injuries, bedside exercises/rehabilitation, and therapeutic nursing interventions (Stotts et al, 2004; Arroyo-Novoa et al, 2008; Chanques et al, 2014). Third, we only measured the frequency of self-reported pain assessments and did not analyse data on the amount of additional medication used or the improvement of analgesia. However, we believe that without improving the process outcome of 'quality of pain assessment', there would be no improvement in the other outcomes related to pain management. Optimal pain assessment is the first step in pain management and is an important indicator of patient progress. Finally, the study design was not prospective. Instead, we used a multivariate analysis to determine the association between the intervention and the incidence of agitation. Therefore, further studies are needed to confirm the effectiveness of NRS-V in the pain management of critically ill patients under mechanical ventilation.

### **Implications for emergency clinical care**

This study's findings suggest that using the NRS-V may improve pain management in the ICU. To optimally manage pain in ICU patients, nurses should perform routine pain assessments. Our intervention for improving pain assessment rates for patients on mechanical ventilation who are awake but unable to communicate verbally, can be adapted according to need and utilised at other ICUs.

## CONCLUSION

The use of NRS-V was associated with an increased use of the pain assessment tool and a decreased incidence of severe pain and agitation in mechanically ventilated patients. An intervention as simple as this can improve pain management in the ICU. For enhanced pain management, nurses should evaluate the pain of mechanically ventilated patients using self-reporting tools.

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